Feeding Preferences of Subterranean Termites, *Odontotermes obesus* (Ramber) (Blattoidea: Termitidae) in Field and Their Control and Developing Bait Strategies

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ABSTRACT

Termites are a social group of animals. They found everywhere except Antarctica. Termites are the major pest of agriculture and damaging wood and wood products. The present study was conducted to evaluate the feeding behavior of termites under field conditions. Eight wood species include *Mangifera indica* (mangoes), *Albizia lebbeck* (albizia), *Populus euramericana* (popular), *Melia azedarach* (bead tree), *Vachellia nilotica* (kiker,thorny acacia), *Eucalyptus camaldulensis* (eucalyptus), *Dalbergia sissoo* (shesham), and *Eugenia jambolana* (jamun) was offered to termites to feed under field trials. Wood species was cut into blocks (L×W×T =8×9×1 cm) and dry in the oven at 42°C for 72 hours. It was found that *P. euramericana*, *M. indica* and *V. nilotica* where the most palatable woods to termite as maximum feeding was noted for these two kinds of wood under field conditions. *M. azedarach*, *D. sisso* and *E. camaldulensis* were lest preferred woods to termite in choice and no-choice bioassays. *M. azedarach, D. sisso* and *E. camaldulensis* have a natural chemical which make the wood resistant against the termite attacks. Chemical extract from these resistant plants can be used in termite control are safer and hazardless for the environment.

INTRODUCTION

In the history of social evolution, termites were the first animal to live together in an organized colony (Wang *et al.,* 2015). Termites live in groups belonging to the order Blattodea Infra order Isoptera). They have active bioreactors that can efficiently decompose lignocellulos (Brune, 2014), hence play a key role in the universal carbon cycle (Sugimoto *et al.,* 2000). Termites (Blattaria: Termitoidae) are found to be common ecosystem engineers and are mainly distributed in tropical ecosystems. They are principal decomposers in tropical forests and savannahs and play a central role in the physicochemical and biological transformation of organic materials and restructuring of soil components (Casalla and Korb, 2019). Approximately 3,000 species of termite have been defined consisting of 7 families and 280 genera. Only 80 species cause damage to

wood and wood structures. Out of these 38 species are subterranean termites (Brune, 2014). *Odontotermes obesus* (Rambur), *Microtermes obesi*, *Odontotermes obesus* (Rambur), *Coptotermes heimi* (Wasmann) (Holmgren) and *Heteroterme indicola* (Wasmann) are the well-known termite species in Pakistan and cause severe damage to wood and wooden structure. *H. indicola* is an important pest of home structures in Pakistan and become a dangerous pest species in Lahore (Manzoor and Mir, 2010). *C. heimi* (Wasmann) is distributed throughout Pakistan and destroy the woods and even standing plantations (Rasib and Hina, 2014).

Termite plays a significant role in the ecosystem as decomposers due to their unique ability to cellulose digestion (Genet *et al.,* 2001) but they are reflected as pests when they damage and destroy the timber structure and any plant materials used by humans. 80 species of termites were found to be pests and cause economic loss and among these 38 species of subterranean, with the genus *Coptotermes* having the greater number of species followed by *Odototermes and Reticulitermes.* In 2010, it was assumed that 32 billion dollars were consumed globally for prevention and damage repair due to subterranean termites (Rust and Su 2012). In Pakistan, Fungus growing termites *Odontotermes* and *Microtermes* species are serious agricultural pests and responsible for the massive loss of agriculture. *Odontotermes obesus and Microtermes obesi* cause severe damage to the green foliage crops in different areas of Punjab including Gojra, Lahor and Qadeer Pur. Sugarcane fields were found to be highly attacked and damaged by the *M. obesi*. Sunflower and wheat are more badly attacked by *O. obesus*. The Indian white termite, *O. obesus* (Rambur) has extensively distributed in central Asia, which results in huge economic losses i.e., fuelwood, damage wooden cabinets, floor timber and railway tracks (Qureshi *et al.,* 2015).

Subterranean Termite Baiting:

Baiting involves the placement of stations around a structure that subterranean termites intercept during foraging. Termites encountering a bait station feed from a cellulose-based food matrix that also contains a slow-acting termiticide. The goal is for most individuals in a colony to feed on the bait and die, resulting in colony elimination (Evans and Iqbal, 2015). The current study was conducted to find the most preferred wood species to termite under field conditions. These woods would be used in baiting stations and for termite trapping.

MATERIALS AND METHODS

Collection of Termite:

Termites were collected from Dhandal, District Sialkot, Pakistan (LAT: 32º11'37"N LONG: 74º31'26"E). A single-trap collection method was used to collect termite. 80% of ethyl alcohol was used to preserve termites for identification in the laboratory. By using the identification keys (Akhtar, 1972) the specimen is recognized as *Odontotermis obesus*. Both workers and soldiers were collected in the warmer month of July.
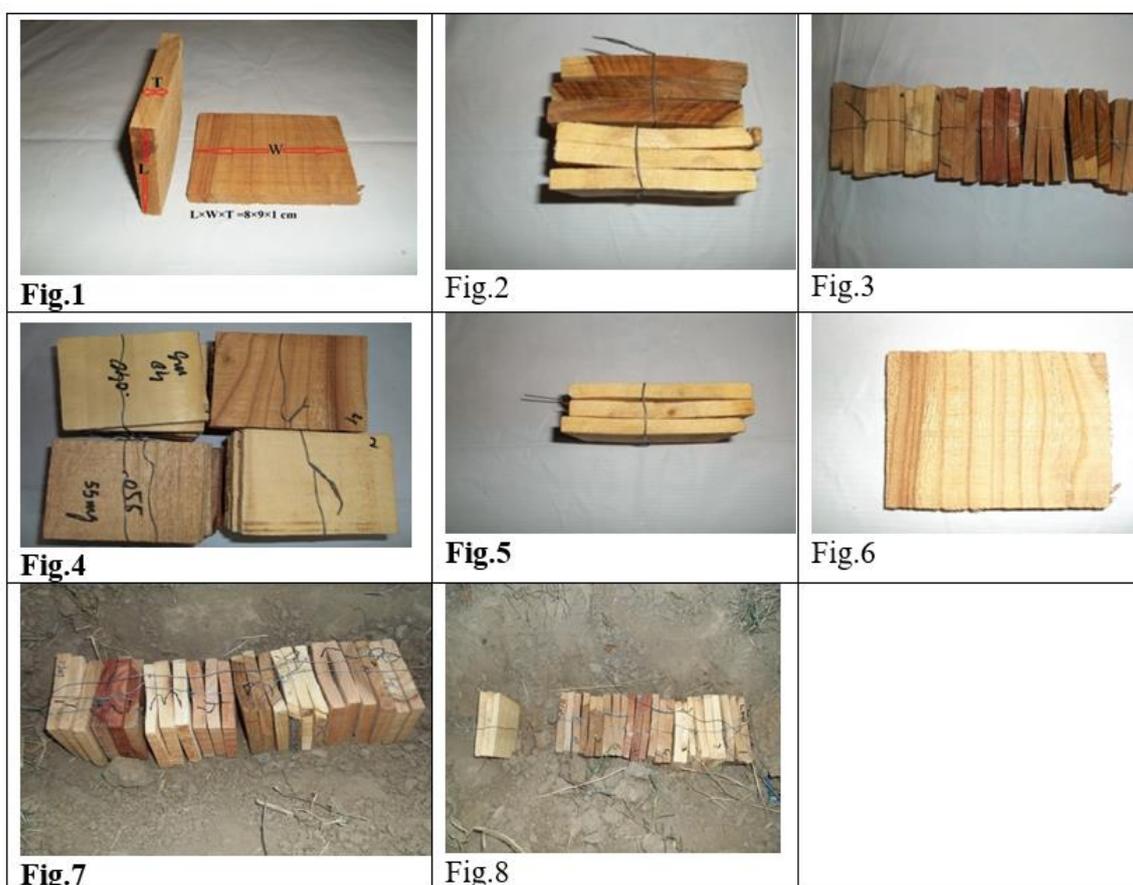
Selection of Wood:

Eight commercially important kinds of wood were selected for field trials. These wood species are given in table including their scientific and common names.

Each wood was cut in blocks of size (L×W×T =8×9×1 cm). Finally, wooden blocks were dried at 42ºC temperature for 72 hours in the oven before exposure to termite.

Table.1: Wood used in the experiment with scientific and common names

Plant Species	Scientific name of plant	English name	Local name
1	*Mangifera indica*	Mangoes plant	Aam
2	*Albizia lebbeck*	Albizia	Shreen
3	*Populus euramericana*	Popular	Popular
4	*Melia azedarach*	Bead tree	Daraik
5	*Vachellia nilotica*	Thorny acacia	Kikar
6	*Eucalyptus camaldulensis*	Eucalyptus	Safaida
7	*Dalbergiasi ssoo*	Sisso	Shesham, tali
8	*Eugenia jambolana*	Jambolana	Jamun

Figs.1-8: Plant species. Fig. 1- Blocks of size (L×W×T =8×9×1 cm), Fig. 2- Block of two wood species tied, Fig.3-Block of eight woods species tied in group (n=3), Fig.4-Wood blocks after calculating the weights, Fig.5 - Three blocks of a single wood species tied with metal wire, Fig.6-Single wood block, Fig.7-Wood blocks in the field, choice bioassay, Fig.8- No choice bioassay.

Control Test:

   P. euramericana was used as a control group under field conditions.

No Choice Bioassay:

   In a no-choice bioassay, only one type of wooden blocks was offered to termites in field trials. Three replicates (n = 3) of each wood species were tied with wire. After

calculating the weight, the blocks were tied with wire and buried 25 to 30 cm deep in the soil for 12 weeks (Fig. 8). At the end of the experiment wooden blocks were washed and dried at 42ºC. The post-weight was calculated by using an electric balance. The quantity of wood consumed in 12 weeks was calculated by using the following formula:

$$WL = \frac{W1 - W2}{W1} \times 100$$

Whereas WL is the wood mass-consumed, W1 and W2 are the pre- and post-weights of the wooden block respectively.

CHOICE BIOASSAY

Choice bioassay was conducted in the field. The wood blocks were arranged in groups. The arrangement of wood blocks was *M. indica* (mangoes) vs *V. nilotica* (kiker, thorny acacia), *A. lebbeck* (albizia) vs *E. jambolana* (jamun), *D. sissoo* (shesham) vs *P. euramericana (popular)* and *E. camaldulensis* (eucalyptus) vs *M. azedarach* (bead tree). After calculating the pre-Weights, wood blocks were tied and buried 25 to 30cm deep in soil for 12 weeks near the termite colony (Fig. 7). Temperature was noted 42 ºC at the time of installation of experiment in the field. The wood consumed by termites in 12 weeks was calculated by using the following formula:

$$WC = W1 - W2$$

Whereas, WC was the mass consumed, W1 and W2 are the pre- and post-weights respectively.

Statistical Analysis:

Paired comparison t-test was used for statistical analysis by using Minitab software version 16.
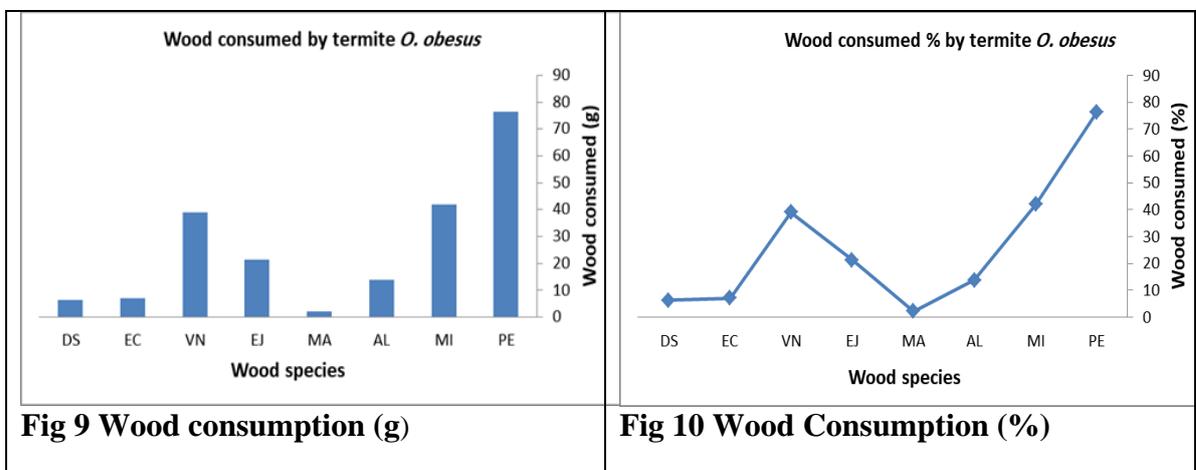
RESULTS

No Choice Bioassay:

In a no-choice field bioassay, 8 different wood species were exposed to termite *Odontotermes obesus.* Among these species, minimum mass loss was recorded in *Melia azedarach* (2.16%). Maximum consumption was noted in *Populus euramericana* (76.38%) after 12 weeks. Current results revealed that, *M. azedarach* is not preferred wood by *O. obesus* and found to be highly resistant wood. Whereas, *P. euramericana* is extremely susceptible to termite attack. The mean wood consumption values noted for *P. euramericana* was 28 g, *M. indica* 21 g, *A. lebbeck* 10 g, *M. azedarach* 1.34 g, *E. jambolana* 12.34 g, *V. nilotica* 26.6 g, *E. camaldulensis* 5.34 g and *D. sisso* 3.67 g. In a no-choice bioassay least feeding was recorded in *M. azedarach* (1.34 g) and maximum infestation observed in *P. euramericana* (28 g) (Table 2).

Table 2: Mean (X ± SD) wood mass loss (g) in eight different blocks of wood exposed to the workers of *O. obesus* in no-choice field trials

Wood species	Wood consumed (g)	Wood consumed %
Populus euramericana (**Control**)	29 ±0.192	78.82
Populus euramericana	28 ± 0.289	76.38
Mangifera indica	21 ± 0.441	42
Albizi alebbeck	10 ± 3.01	13.76
Melia azedarach	1.34 ± 0.15	2.16
Eugenia jambolana	12.34 ± 1.47	21.28
Vachellia nilotica	26.6 ± 0.291	39.11
Eucalyptus camaldulensis	5.34 ± 0.434	7.03
Dalbergia sissoo	3.67 ± 0.294	6.33

The results of no choice bioassay presented a comparable pattern of mass losses as in choice bioassay. Woods are different meaningfully in terms of mass loss (g) and percentage mass loss. The highest (76.38%) wood consumption was noted in *P. euramericana*. The least mass losses were observed in *M. azedarach* (2.16%), *D. sisso* (6.33%) and *E. camaldulensis* (7.03%). Deep penetration was observed in *P. euramericana* (76.38%), *M. indica* (42%), *and V. nilotica* (39%). Superficial to medium attack was observed in *E. jambolana* with (21.28%) mass loss (Fig 9, 10).

Fig 9 Wood consumption (g)   **Fig 10 Wood Consumption (%)**

Choice Bioassay:

A variety of wood is present in the environment to consume by termites. The behavior of termite depends on the wood quality used in the bait. The woods are different in properties due to the presence of chemicals and it may affect the preference of termite. The preference of *O. obesus* to different woods is different. This might be due to different environmental factors. Wood moisture, hardness, wood degraded by fungus, chemicals in wood, temperature and termites species in an area and soldier and workers ratio affect the feeding.
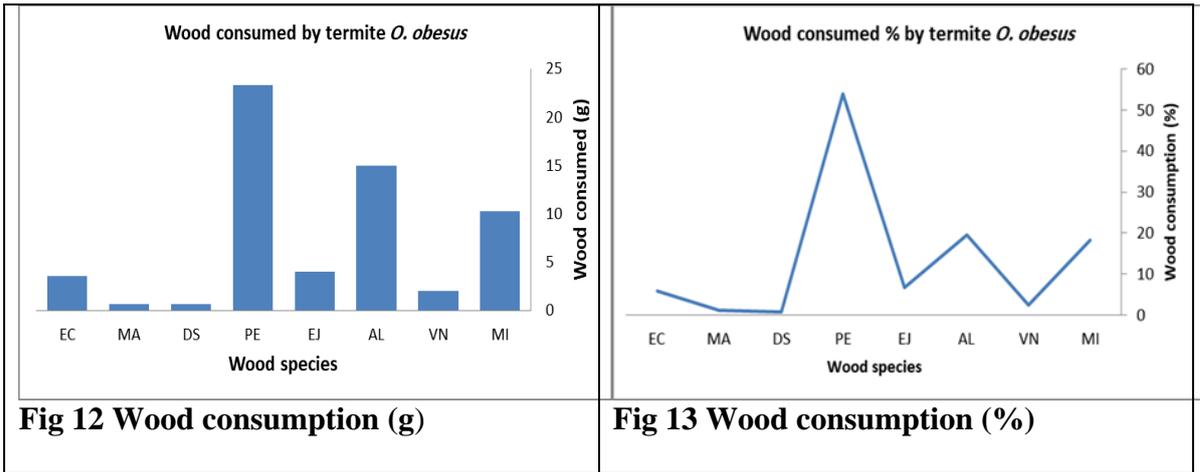
Fig.: 11(a-h). Wood affected by termite *O. obesus* in a no-choice bioassay
Choice bioassay

Among the woodblocks, offered to termite *O. obesus* is a combination of two kinds of wood in choice bioassay under field conditions, the maximum feeding was noted in *P. euramericana* and *D. sisso* (23.3 and 0.67 g) and minimum feeding were recorded in *M. azedarach* and *E. camaldulensis* (0.67 and 3.6 g). Feeding preferences of termites for the combinations in descending order were as follow: PE/DS> AL/EJ > MI/VN > MA/EC. The difference in a mass loss for each pair of wood blocks was significantly different (P < 0.05, paired comparison t. test) (Table 3).
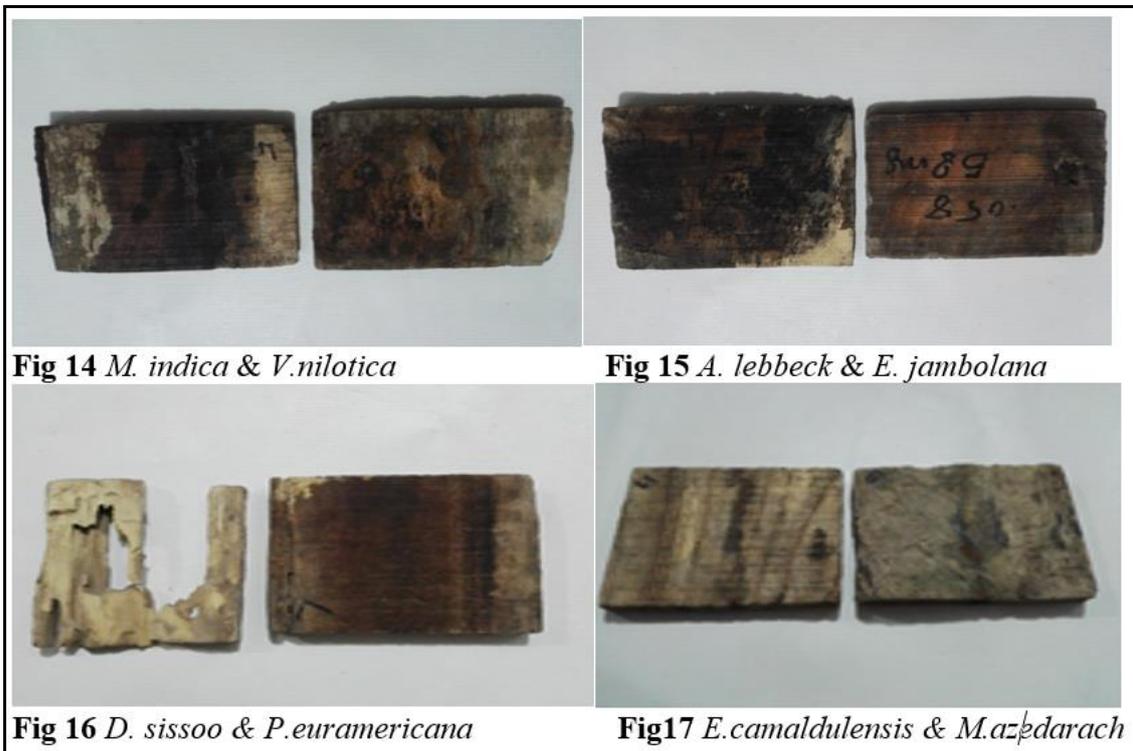
Table: 3. Mean (X ± SD) wood mass loss (g) in four different wood pairs exposed to the workers of *Odontotermes obesus* for MI/VN *(Mangifera indica* and *Vachellia nilotica)* AL/EJ *(Albizia lebbeck* and *Eugenia jambolana)*, PE/DS *(Populus euramericana and Dalbergia sissoo)* and EC/MA *(Melia azedarach and Eucalyptus camaldulensis)* in 12-week choice experiment under field conditions

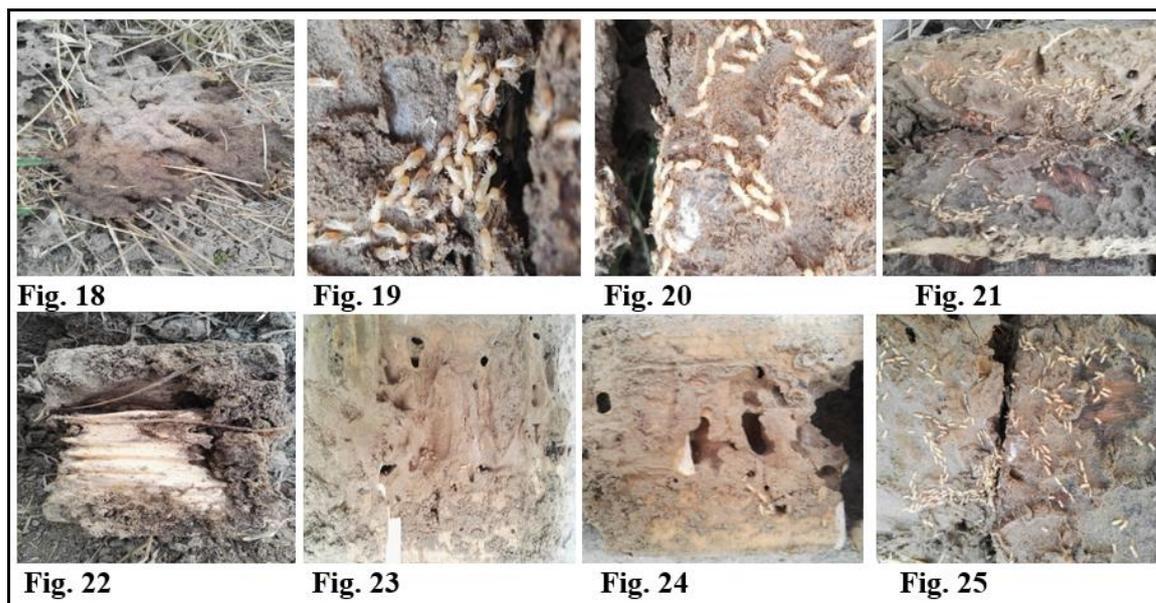| Wood mass loss (g)			
Comparison	**Wood 1**	**Wood 2**	**Probability**
MI/VN	10.3±0.145	2.0±0.145	0.001
AL/EJ	15.0±0.260	4.0±0.289	0.001
PE/DS	23.3±0.208	0.67±0.123	0.000
MA/EC	0.67±0.241	3.6±0.291	0.001

Figure (12) shows that maximum feeding (23 g) was recorded in *P. euramericana* and the least mass loss was noted in *D. sisso*, *M. azedarach* and *E. camaldulensis*. *P. euramericana*, *A. lebbeck* and *M. indica* were significantly preferred wood to *O. obesus*.

Fig 12 Wood consumption (g)   **Fig 13 Wood consumption (%)**

Maximum feeding (53 %) was observed in *P. eumericana*. It is the most preferred food source of *O. obesus* (Fig 16). *D. sisso, M. azedarach* and *V. nilotica* were significantly less preferable woods in choice bioassay (1.02, 1.15 and 2.56 %). Results of choice bioassay indicated that *P. eumericana, A. lebbeck* and *M. indica* suffered heavy attack. *D. sisso, M. azedarach, V. nilotica* and *E. camaldulensis* were rated as superficial to medium attack (no deep penetration). The highest attack was observed in *P. eumericana*. Termite deeply penetrated in *P. eumericana* and 23 g wood was consumed (Fig 16). Some woods are least preferred like *M. azedarach*. This is due to the presence of some natural chemicals.

Fig 14 *M. indica & V.nilotica*   **Fig 15** *A. lebbeck & E. jambolana*

Fig 16 *D. sissoo & P.euramericana*   **Fig17** *E.camaldulensis & M.azedarach*

Figs. 14-17: Woods affected by the termites in choice bioassay.

Figs. 18-25: Woodblocks infestation by termite picture by Kodak Camera 14 Megapixel

DISCUSSION

The current study found that *P. euramericana, V. nilotica*and *M. indica* woods were the favorite food source to termite *O. obesus.* Maximum feeding and mass loss was observed in these woods in both tests. Softening of *P. euramericana* and *M. indica* makes these woods palatable to termite. More than 70% consumption was noted in the case of *P. euramericana.* Visually, it was found that these woods were heavily attacked, even the woods were collapsed. Termites were penetrated inside the woods and maximum wood was consumed. In comparison, heartwoods of *A. lebbeck*, *M. azedarach, E. camaldulensis, E. jambulana,* and *D. sisso* have not desired wood species. Minimum wood consumed in case of these woods and fall under the category of "slight to superficial attack". Among these woods, *M. azedarach, D. sisso* and *E. camaldulensis* were found to be most resistant to termites. Only 1.34 g wood *M. azedarach* was consumed in no choice (Table 2) and 1.15 g in choice bioassay (Table 3) and *E. camaldulensis*was consumed 3.6 g in choice bioassay (Table 3) and 7.3 g in a no-choice bioassay (Table 4). *D. sisso* was consumed 3.67 (g) in no choice and 0.67 (g) in choice bioassay. *P. euramericana* and *M. indica* are the favorite woods to termites under different environmental conditions and can be used in termite trapping and bait station (Figure 16, 18-25).

The efficiency of the bait station to destroy and eliminate the colonies of termites in the fields can be improved and enhanced by selecting appropriate wood, size of bait station and placement of bait. Wood possesses different characteristics. Wood density, nutritional values and the presence of chemicals in them make the wood different from others. Therefore, more suitable and palatable wood is much important in trapping a larger number of termite workers in the monitoring station. Wood softness and palatability attract a larger number of termite workers in the baiting station. A recent study has shown the preference of *O. obesus* to 8 local wood species. Amongst the 8 wood species examined in the choice and no-choice bioassay, the *P. euramericana* and *M. indica* trees were found to be the most palatable wood species since the *O. obsus* workers removed more mass from these two kinds of wood. Due to its lightweight and softness, *O.obesus* preferred a populous tree. Previous studies showed that softwoods are easy to eat and chew as compared to hardwoods; therefore termites prefer softwood to

feed. The wood hardness is a key factor in wood-feeding by subterranean termites with maximum mass consumption rates for softwood compared to hardwood species *(*Peralta *et al.,* 2004*).*

Furthermore, the wood of *P. euramericana* populous is more susceptible to degradation by the microorganism i.e., fungus and the wood degraded by the fungus is usually preferred by termite workers (Little *et al.,* 2013). Rasib *et al.,* (2014) reported that the woods of *P. euramericana* and *M. indica* were the most palatable and favorite food source to termite *O. obesus* in both choice and no choice bioassay. Both wood species are soft and easily consumable. Rasib and Hina (2014) also reported that *P. euramericana* populous was highly preferred wood to *Coptotermes heimi* in both laboratory and field bioassay. Therefore *P. euramericana* populous can be used in the bait station and termite trapping. The current study found that *P. euramericana* and *M. indica* are the most preferred and palatable wood species and can be used in termites tramping and for successful bait stations. On the other hand, *M. azedarach*, *D. sisso* and *E. camaldulensis* were not preferred wood species to *O.obesus,* minimum infestation was noted visually and experimentally in both choice bioassay and no choice bioassay. Due to the presence of different chemicals in the sapwood (Huang and Chen, 1981) that had prevented the workers of *O.obesus.* Chemicals present in the lignocellulosic tissue makes the wood resistant to termite attack. Currently, we did not find out the chemicals present in the sapwood of *Melia azedarach* beads tree and *E. camaldulensis* eucalyptus which make the wood resistant to termite attacks. Future studies could be important in finding such chemicals to utilize in termite control.

Conclusion

Recently, baiting is a new technique for the management of termite infestation all over the world. Effective baiting requires the recruitment of a larger number of termite workers in the baiting stations. The current study indicates that woods of *P. euramericana* and *M. indica* are competently applied in the bait station to increase the efficiency of baiting against *O. obesus.* In developing countries, including Pakistan baiting studies have not been given proper attention. This technique requires the usage of some food material in the baiting station to attract a huge number of termite workers. The current study showed that *P. euramericana*, *M. indica* and *V. nilotica* the most preferred and palatable wood species to *O. obesus*. These woods can be used for a successful baiting program against the *O.obesus.* It's also helpful in increasing the percentage of monitoring devices and lowers the costs of baiting. *M. azedarach* (bead tree), *D. sisso* and *E. camaldulensis* have a natural chemical that makes the wood resistant against termite attacks. Chemical extract from these resistant plants can be used in termite control are safer and hazardless for the environment.

Acknowledgements

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